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Effects of Visual and Olfactory Stimulation on Parotid Secretion Rate in the Human[1] (38259)

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It is generally accepted that speaking of food, as well as seeing or smelling food, induces a profuse secretion of saliva. If salivary flow can be affected by factors such as verbal exchanges and visual influences, then studies in which rate of flow changes could influence results must be reevaluated and future experiments should include a careful control over such factors.

There is evidence in the literature that verbal reference to food and/or the sight of food increases saliva secretion (1–10) but, conversely, others (11–15) have reported that no such increases result under these conditions.

While olfactory stimulation has generally been found to increase the rate of salivary flow, agreement is not universal on whether this is a conditioned response or a true reflex mechanism (3, 14, 16, 17).

The present study explores these controversies by measuring the effects of seeing lemons cut and squeezed, of cutting and squeezing lemons, of suggesting to subjects that lemon juice is extremely sour and of smelling freshly cut lemon.

Materials and Methods. Several factors were constant throughout the entire study. All subjects were healthy, young, adult males. Experiments were undertaken between 6:30 and 7:00 a.m. with subjects in the fasting state. All parotid saliva collections were made with a dual-chambered, vacuum-maintained, metal collector (18) and sampling periods, both control and test, invariably included 20 min. All subjects were instructed not to undertake oral movements of any sort during the collection periods.

Twenty subjects participated in the first experiment. A control 20-min parotid sample was first collected from each subject. This was followed by a similar period during which the subjects watched a technician cut and squeeze lemons into a glass beaker. This was accomplished within a fume hood to eliminate olfactory stimulation.

In the second experiment, parotid saliva samples were collected from five subjects with each sampled daily over a 10-day period. The control 20-min collection was followed by a 20-min interval during which the subject watched the cutting and squeezing of lemons. In addition, the technician commented throughout the period on the extremely sour taste of lemon juice and suggested repeatedly that biting a lemon, or even seeing one squeezed, caused profuse salivary flow.

In the third experiment, five subjects were sampled on 5 successive days. After a 20-min control collection, a second sample was taken with each subject sniffing a freshly cut piece of lemon every 15 sec. After a 10-min rest period to clear the olfactory stimulus, each participant provided a second control sample.

A group of five different subjects participated in the fourth experiment. It included four 2-day phases and in all instances a series of three 20-min samples was col-

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lected daily. The first and third samples were controls and the second was the test collection. In phases one through four, the test sample was taken while the subjects: (a) watched lemon cut and squeezed, (b) cut and squeezed lemons (nose-clamped and gloved), (c) cut and squeezed lemons (nose-clamped), and (d) sniffed freshly cut lemon.

Results. Parotid flow rate responses for 20 subjects watching lemons being cut and squeezed are outlined in Fig. 1. The difference between flow rate means for the control and test periods, 0.039 and 0.041 ml/min, was not significant.

Fifty pairs of control and test samples were available for analysis in the study involving both visual and suggestive influences related to cutting and squeezing lemons. Results for individual subjects and for the group are presented in Table I. The control flow rate mean, 0.039 ml/min, decreased, but not significantly, to 0.034 ml/min, over the interval of visual exposure to the lemon.

Flow rate results for the third experiment are shown in Fig. 2. Smelling freshly cut lemon increased the control flow rate mean, 0.040 ml/min, to 0.105 ml/min, a 2.6-fold elevation. The post-olfaction mean of 0.044 ml/min did not differ significantly from that for the initial control sample, but the increase with olfactory stimulation was highly significant ($P < 0.01$).

Table II presents results for the final experiment. The flow rate mean for the test sample did not differ significantly from its controls except when olfactory stimulation was a factor. Sniffing freshly cut lemon at 15-sec intervals elicited a significant ($P < 0.01$) increase in secretion rate.

TABLE I. The Effect of Viewing Lemon-Cutting on Parotid Flow Rate.

Subject number	Parotid flow rate (ml/min)			
	Unstimulated		Viewing lemon	
	Mean	SD	Mean	SD
1	0.030	0.012	0.024	0.011
2	0.036	0.010	0.029	0.010
3	0.034	0.013	0.030	0.013
4	0.035	0.011	0.037	0.011
5	0.057	0.018	0.048	0.012
All subjects	0.039	0.016	0.034	0.016

Discussion. Early reports by Zebrowski (1), Gley and Mendelssohn (2), Lashley (3), Winsor (4) and Krasnogorski (5) noted increases in the rate of parotid secretion while subjects viewed or handled foods.

Additional recent work has supported these observations. Hayashi and Aarie (6) found increases in parotid flow when their subjects viewed biscuits and fruits. Jenkins and Dawes (7) reported elevations in whole saliva flow when subjects thought of

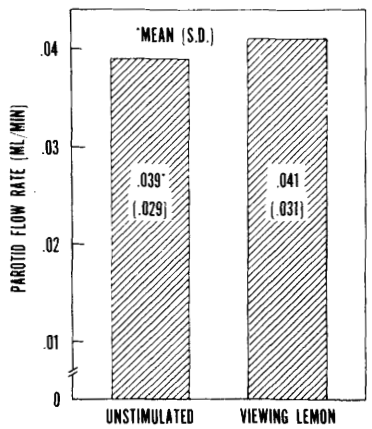

FIG. 1. Effect of watching lemons being cut and squeezed on parotid flow (20 subjects).

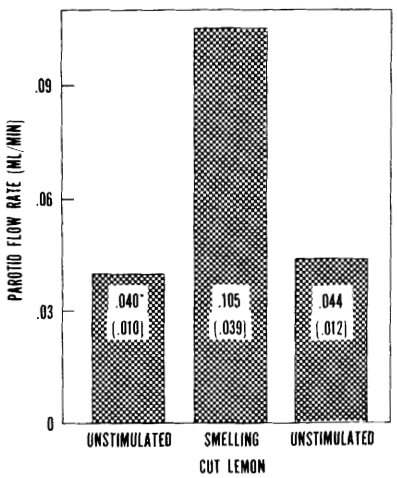

FIG. 2. Olfaction and parotid flow (5 subjects; 5 days).

TABLE II. Parotid Flow Under Varying Experimental Conditions.

Experimental conditions	Parotid flow (ml/min)					
	Control sample		Test sample		Control sample	
	Mean	SD	Mean	SD	Mean	SD
Watching lemon cut and squeezed	0.065	0.044	0.063	0.038	0.074	0.041
Cutting, squeezing lemon (nose-clamp and gloves)	0.071	0.048	0.074	0.048	0.081	0.038
Cutting, squeezing lemon (nose-clamp)	0.066	0.023	0.075	0.037	0.074	0.031
Sniffing cut lemon	0.066	0.037	0.114	0.062	0.060	0.039

food or watched the eating of a lemon. Pangborn (8) reported increases in parotid flow in some subjects while viewing, handling or smelling a lemon.

Staats and Hammond (9) collected saliva by placing cotton rolls in the floor of the mouth over 20-sec intervals. They repeated nonfood or food words (roast beef, French fries, lobster, ice cream, etc.) to 43 subjects and found that all subjects salivated whole saliva at an increased rate ($P < 0.001$) in response to food words.

Wooley and Wooley (10) measured flow with cotton rolls and found increased salivation with every subject when there was a real or imaginary exposure to appetizing food. The salivary flow response to food exposure was significantly correlated with the degree of hunger expressed by the subject ($r = 0.75$) and his impression of the degree of appeal of the food ($r = 0.46$). They concluded that this secretory response was a valid measure of appetite.

There are results, however, that question the presence of salivation increases under these conditions. Brunacci (11), as well as Richter and Wada (12), found no increase in saliva flow during the sight or handling of food.

Winsor (13) spoke of food with a subject who had been without food for 3 days, and could detect no alteration in parotid flow. Delse and Feather (15) reported that subjects did not increase salivary secretion rates while thinking of appetizing foods.

Kerr (14) suggested the idea of food to 50 subjects (10 individually and two groups of 20 each) and found no instances of increased flow in either parotid, submandibular or whole saliva. In some subjects he noted a suggestion of flow inhibition by these suggestions. He also found no changes in secretion rate associated with seeing a lemon, viewing the squeezing and sucking of lemons, handling unwrapped candies, talking of hunger and food, watching food being cooked, or cutting food with a knife and fork. When subjects were allowed to smell a cut lemon, he found an appreciable increase in salivary flow.

A report by Lashley (3), with no data provided, stated that while parotid flow could be increased by olfactory stimulation with volatile oils, the only food odor that increased flow in his work was that of fresh toast. He questioned the existence of a direct olfactory–salivary reflex and felt that when flow increases were present they resulted from conditioning.

Elsberg, Spotnitz and Strongin (16) reported that the injection of air into the nostrils did not affect parotid flow but that adding either menthol or citral to the air stream induced two- to fourfold increases. The increase in flow was found only in the ipsilateral gland. It was concluded that this was indeed a direct olfactory–salivary response.

Grisogani (17) found that parotid flow could be both increased and decreased by olfactory stimulation. Pleasant smelling oils increased glandular function but unpleasant

odors decreased the rate of flow. When the two odors were mixed, the unpleasant odor prevailed and secretion rate decreased.

Kerr (14) saw no reason to classify flow rate increases resulting from olfactory stimulation as conditioned responses and felt that they represented a direct olfactory–salivary reflex in the same fashion as taste responses.

The results of the present study confirm that, commonly held beliefs notwithstanding, viewing lemons being cut and squeezed, as well as the actual cutting and squeezing of lemons, does not increase parotid salivary flow. The impression that saliva flows into the mouth under these conditions is misleading and results simply from the fact that such experiences bring an increased awareness of the presence of the saliva pooled in the floor of the mouth.

Summary. Experiments were conducted to test the effect of cutting, squeezing and smelling lemons on the rate of parotid gland function.

Viewing the cutting and squeezing of lemons did not significantly alter parotid flow. No effect on secretion rate was observed even when the subjects performed the cutting and squeezing.

Smelling freshly cut lemons invariably produced significant elevations in parotid flow.

These results authenticate the existence of a direct olfactory–salivary reflex and dispute the widely held concept that the thought and sight of food induces spontaneous salivary secretion.

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